protection that they are afforded under the current rules. This protection could arise from specifying the frequency roll-off, as is done in current regulations, or by defining the temperature limit that unwanted emissions must meet to successfully operate under the interference temperature model.

A separate but equally important issue with respect to adjacent band emissions is how to take them into account when establishing the interference temperature limit within a frequency band. Because, even if the interference temperature limit in a particular band is well below the permissible limit, an unlicensed device's unwanted emissions could cause the interference temperature limit in an adjacent band to be exceeded, particularly if the interference temperature in the adjacent band is very close to the permissible limit and reflects the cumulative effect of many unlicensed devices. For example, in the RNSS frequency bands used by GPS there are no in-band, ground-based transmitters permitted. However, there is a concern that the cumulative effect from transmitters operating outside the RNSS bands can impact the GPS receiver noise floor. The potential sources of interference to GPS receivers include adjacent band emissions from MSS METs; harmonic emissions from television transmitters; spurious and harmonic emissions from 700 MHz commercial base, mobile, and portable transmitters; and unwanted emissions from unlicensed devices. These multiple sources of potential interference, which might individually be tolerated by a GPS receiver, could combine under certain circumstances (e.g., close separation distances, operating at the maximum allowable out-of-band emission level) to create an aggregate interference level that could prevent the reliable reception of the GPS signal.

NTIA believes that if implemented properly, the interference temperature model can be used to protect adjacent band licensed systems. NTIA recommends that when establishing the

interference temperature limits the emissions from licensed and unlicensed systems operating in adjacent or harmonically related frequency bands be taken into consideration.

XVIII. ADDITIONAL PROVISIONS ARE NOT NECESSARY TO PROTECT DEEP SPACE NETWORK RECEIVERS IN THE 12.75-13.25 GHz BAND LOCATED AT THE GOLDSTONE COMPLEX.

In the NPRM, the Commission proposes to permit unlicensed devices operating at a maximum EIRP of 36 dBm in the 12.75-13.25 GHz frequency band. This band is allocated to the federal and non-federal space research service for reception at Goldstone, California. The Commission does not believe that its proposal will be detrimental to space research operations. The Commission tentatively concluded that since Goldstone is located in a rural location with natural shielding by virtue of its location in a valley, very few, if any, unlicensed devices would be operated in locations that could impact its operations. The Commission requests comment on this tentative conclusion.[84]

Every U.S. deep space mission is designed to allow continuous radio communications with the spacecraft. Continuous 24-hour coverage for several spacecraft requires several earth-based stations at locations that compensate for the earth's daily rotation. The locations in Spain, Australia, and California are approximately 120 degrees apart in longitude, which enables continuous observation and suitable overlap for transferring the spacecraft radio link from one complex to the next.

The National Aeronautics and Space Administration (NASA) Goldstone complex is located on the U.S. Army's Fort Irwin Military Reservation, approximately 72 kilometers (45 miles) northeast from the nearest populated city. The Goldstone complex is situated in semi-mountainous, bowl shaped terrain to shield against radio frequency interference. The 70 meter

84. NOI/NPRM at ¶ 39.

antenna is the largest, and therefore the most sensitive, Deep Space Network (DSN) antenna, and is capable of tracking a spacecraft traveling more than 16 billion kilometers (10 billion miles) from the Earth. Given the importance and the sensitivity of the DSN antenna an analysis was performed to determine the impact on DSN receivers based on the Commission's proposed EIRP level for unlicensed devices operating in the 12.75-13.25 GHz frequency band. The results of the analysis provided in Appendix B indicate that an unlicensed device operating at an EIRP density of 36 dBm/MHz would have to be within approximately 16 km of a DSN antenna before potential interference occurs. At an EIRP density of 36 dBm/20 MHz the separation distance reduces to approximately 8 km.

Protection of the spectrum used by the DSN receivers is essential for safeguarding data communications capabilities between spacecraft and the Goldstone tracking antennas. The remote location of the Goldstone complex provides protection for the sensitive DSN receivers from local interference. Given the geographically remote location of the Goldstone complex, interference to DSN receivers will only be encountered when the unlicensed devices are operated on the Goldstone complex by NASA or Department of Defense personnel. It is believed that the existing spectrum coordination and monitoring activities will ensure that DSN receivers are protected from interference caused by unlicensed device operations. Thus, NTIA agrees with the Commission's tentative conclusion, and no additional provisions are necessary to protect the DSN receivers at the Goldstone complex.

XIX. TECHNICAL ISSUES RELATED TO THE COMPLIANCE MEASUREMENTS OF UNLICENSED DEVICES THAT EMPLOY THE INTERFERENCE TEMPERATURE MODEL MUST BE ADDRESSED.

Transmitters must be tested to show compliance with the applicable requirements before they can be certified. For unlicensed transmitters, both the technical requirements and the test

procedures are specified in Part 15 of the Commission's Rules. In the NOI, the Commission discusses several actions that may be taken by an unlicensed device when its emissions cause the interference temperature limits to be exceeded at the licensed receiver. For example, the unlicensed device could select a different transmitting frequency; cease transmitting for a period of time; decrease its power using automatic transmitter power control; or electrically re-shape its antenna pattern.[85] The NOI does not address technical issues related to compliance measurements of unlicensed devices that employ the interference temperature model.

The technologies contemplated in this NOI reach far beyond the traditional methodologies employed in device certification. For example, measurement of transmitter power across a given frequency range is insufficient to ensure that dynamic systems are functioning properly. Telecommunication Certification Bodies (TCB) are responsible for performing the compliance measurements, including those of unlicensed devices operating under Part 15 of the Commission's Rules. The introduction of unlicensed devices employing the interference temperature model will raise technical issues that need to be addressed specifically with respect to the TCBs. In the Commission's NPRM on cognitive radio technology, many of the compliance measurement issues that will be encountered by devices employing interference temperature are also being addressed.[86] As indicated in the Commission's NPRM on cognitive radio technologies, many new technical issues must be resolved to show that a device is compliant with the Commission's Rules. Many of the same compliance measurement issues must be resolved for devices employing the interference temperature model. For example, for devices employing DFS, these technical issues can include determining the frequency bands that

85. NOI/NPRM at ¶ 13.

86. Cognitive Radio NPRM at ¶¶ 99-107.

are to be monitored, the monitoring bandwidth, the sensitivity of the monitoring receiver, the ability of the device to select an operating frequency and power level based on the presence of various standardized test input signals, the monitoring period and revisit time, and the time required to move off of a frequency once the interference temperature limit is exceeded. For devices employing geo-location techniques, compliance measurement issues related to the ability to correctly identify their location based on geo-location technology and the ability to access a database and correctly determine the location of authorized transmitters must be addressed. TCBs must be required to develop new capabilities in both the test equipment available, and the expertise of their technical staff in order to certify devices utilizing these new technologies.[87]

In the past, because of their simplicity, the compliance measurement procedures were typically considered after the development of the service rules. However, given the complexity of the devices that employ technologies capable of modifying operating characteristics that can change their electromagnetic compatibility with other devices, the compliance measurement procedures must be addressed at the same time the service rules are developed. The TCBs are the experts in the area of performing the compliance measurements and need to be actively engaged in providing guidance on the technical issues related to device certification. NTIA believes that technological approaches that cannot be verified in the TCB laboratories should not be relied upon for successful spectrum sharing using the interference temperature model. NTIA recommends that the Commission resolve the technical issues related to performing the compliance measurements prior to implementing the interference temperature model.

87. *See* 47 C.F.R. § 2.962 (b). Under the Commission's Rules, to be designated as a TCB, the TCB is required to demonstrate expert knowledge of the regulations for each product with respect to which the body seeks designation. Such expertise includes familiarity with all applicable technical regulations, administrative provisions or requirements, as well as, the policies and procedures used in the application thereof. The TCB is required to have the technical expertise and capability to test the equipment it will certify.

XX. THE INTERFERENCE TEMPERATURE LIMITS IN A FREQUENCY BAND SHOULD BE BASED ON THE MOST SENSITIVE RADIO SERVICE OPERATING IN A BAND.

There are many instances where several radio services share the same frequency band on a primary and secondary basis. In the frequency bands where several radio services share the spectrum on a primary or secondary basis, the Commission requests comment on whether the interference temperature limit should be based on all the licensed services or only on the service that is most susceptible to interference.[88]

In frequency bands where several radio services share the spectrum on a primary or secondary basis, the interference temperature limit for unlicensed devices should be established to protect all licensed services. If this approach is not used, unlicensed devices would enjoy a higher status than the secondary services operating in the band. This would result in less, not more regulatory certainty for the incumbent services than under the current regulatory framework. The primary service in a frequency band is not always the most susceptible to interference. In the particular case of radio astronomy, observations are carried out successfully in several bands where the radio astronomy service has a secondary allocation, and is the most sensitive service. For example, the 14.47-14.7145 GHz band is shared between the fixed, mobile, and fixed satellite services on a primary basis with radio astronomy operations on a secondary basis. In this band, extensive coordination agreements or other regulatory approaches can be used such that the secondary radio astronomy operations can co-exist with the other primary services, which is not possible with unlicensed devices. If the interference temperature in the 14.47-14.7145 GHz band were based on only the primary services, the permissible level of interference could be approximately 72 dB higher than the level necessary to protect the radio

88. NOI/NPRM at ¶ 21.

astronomy observations.[89] If an interference temperature limit is established in a band in which both primary and secondary allocated services operate, NTIA recommends the limit should be based on the most sensitive radio service operating in the frequency band.

XXI. INTERFERENCE TEMPERATURE MEASUREMENTS MADE BY A SATELLITE RECEIVER CANNOT BE USED TO PROTECT GROUND-BASED RECEIVERS.

In the NOI, the Commission describes a number of approaches to perform adaptive or real-time interference temperature measurements by which monitored information regarding spectrum occupancy could be transmitted back to individual unlicensed devices.[90] For example, the Commission believes that satellites could monitor the $\Delta T/T$ and make the measured data available to individual devices, which in turn could adjust their operation to ensure that they do not interfere with licensed operations. The Commission requests comment on the utility and potential benefits of such a real-time monitoring approach in the 6525-6700 MHz and 12.75-13.25 GHz bands, as well as other frequency bands. Comments are also requested on how the monitored information could be acquired by the unlicensed devices.[91]

The interference level at a satellite receiver that results from a large number of ground-based unlicensed devices operating within the footprint of the satellite will cause an increase in the $\Delta T/T$ level in the satellite receiver. The effective interference at the satellite receiver would be an aggregate from a large number of unlicensed devices. This aggregate signal results from ground-based devices where each device is essentially the same distance from the satellite

89. The permissible interference level for land mobile operations is approximately -146 dBW, whereas the maximum permissible interference level to protect radio astronomy operations, based on Recommendation ITU-R Recommendation RA.769 in the 14.44-14.5 GHz band, is -218 dBW.

90. NOI/NPRM at ¶ 37.

91. *Id.* at ¶ 51.

receiver, thus there cannot be a single dominant device. However, the measured ΔT/T level at the satellite receiver is only applicable for assessing potential interference to a satellite receiver. In the case of the ground-based radio services (e.g., fixed, mobile), the potential interfering unlicensed devices can operate in close proximity to the ground-based receiver. Unlike interference to a satellite uplink receiver, a single unlicensed device could be the dominant factor in establishing the effective interference power level at a ground-based receiver. The interference interactions between satellite and ground-based receivers and ground-based unlicensed devices are completely different. Thus, it does not appear possible to use the interference levels measured by a satellite receiver to control the operating characteristics of unlicensed devices to the extent necessary to protect licensed ground-based receivers.

Using satellites to make measurements of the noise within a frequency band has been ongoing for years. Government and commercial satellite systems monitor geophysical, metrological, and environmental conditions on the Earth. These satellite systems are capable of measuring small changes in the noise, and the data is downloaded (not on a real-time basis) for use in long-term weather prediction models. However, using this measured data on a real-time basis to control the operating characteristics of a ground-based transmitter has not been attempted. Recently, a system has been proposed by Mobile Satellite Ventures (MSV) that will monitor ancillary terrestrial component (ATC) emissions within the footprint of their satellite.[92] The purpose of this monitoring is to provide assurance that the level of ground-based co-channel interference (e.g., ΔT/T) as seen by other satellite systems remains below acceptable levels. In the MSV proposal the aggregate signal level at a particular co-channel frequency generated by

92. Mobile Satellite Ventures *Ex Parte* Presentation, IB Docket No. 01-185, *Monitoring and Control of Ancillary Terrestrial Emissions by MSV's Space Segment* (March 28, 2002).

ATC operations within each satellite cell will be monitored. By combining the co-channel contributions from all satellite cells containing ATC components, the total (aggregate) co-channel signal generated by the entire ATC network can be measured and recorded. Using a closed-loop feedback control, a centralized controller can set the appropriate limits on ATC emissions if interference begins to approach a specified level. The proposed monitoring system will use logarithmic amplification to detect relatively small changes in the noise floor.[93] The proposed monitoring system will also have the means to self calibrate to noise levels in the absence of ATC emissions. MSV specifically states that the monitoring and control of ATC emissions can only work in a satellite system that is completely integrated and coordinated between the space and ground-based segments with the real time control of information between the two.[94] The approach being proposed by MSV appears to be similar to that envisioned by the Commission. MSV plans to use this approach to ensure that their ATC system does not interfere with in-band Inmarsat operations. NTIA recommends that the Commission monitor the MSV system as it is implemented, and possibly establish a limited test program in the 6 or 13 GHz frequency bands based on this approach.

It appears there are possible approaches that can be used to make measurements of $\Delta T/T$ levels in frequency bands used by satellite uplinks. However, it is unknown if the measured $\Delta T/T$ levels can be used to prevent unlicensed ground-based transmitters from interfering with a satellite receiver, especially if the satellite and ground-based transmitters are not operating under a central controller. For example, if the $\Delta T/T$ limit is exceeded, it is unclear what factors would be used to determine which devices would modify their operating characteristics (e.g., turn off

93. *Id.* at 3, 13.

94. *Id.* at 3.

all or some percentage of devices, incrementally reduce power for all devices). NTIA believes that the interference interactions between satellite and ground-based receivers and ground-based unlicensed devices are completely different. Thus, NTIA does not believe it is possible to use the $\Delta T/T$ levels measured by a satellite receiver to control the operating characteristics of unlicensed devices to the extent necessary to protect licensed receivers operating in frequency bands used by the ground-based radio services (e.g., fixed, land mobile, radiolocation).

XXII. BASELINE MEASUREMENTS IN SELECTED LICENSED AND UNLICENSED FREQUENCY BANDS SHOULD BE PERFORMED BEFORE DECIDING WHETHER OR NOT THE INTERFERENCE TEMPERATURE MODEL CAN BE IMPLEMENTED.

The Commission states that the noise floor has increased at various points, which are indicated by peaks above the original noise floor shown on Figure 1 in the NOI.[95] In between the peaks, the level is close to the original noise floor. The Commission believes that by allowing the entire noise floor in a band to increase to the levels represented by the peaks, greater access by higher-powered unlicensed devices is possible. The Commission proposes that the interference temperature limit should be set at this elevated noise level.[96]

There are two problems with the interference temperature model as proposed by the Commission. First, increasing the overall noise level in a frequency band will not necessarily permit more opportunistic use of the spectrum by higher-powered unlicensed devices. As shown in Appendix E, an elevated noise level will impact both licensed and unlicensed users equally. Therefore, if the noise is elevated, a higher transmitter power is necessary to achieve the same range that was obtainable in a lower noise environment. The study performed by the Naval

95. NOI/NPRM at ¶ 15.

96. *Id.*

Postgraduate School reviewed a limited set of measured data in the 2.4 GHz unlicensed band and stated that there is a serious concern about saturation of the present unlicensed bands and the degradation in system performance that accompanies spectrum saturation.[97] The Commission's Technical Advisory Council (TAC) also raised Concerns regarding the degradation of the noise environment.[98]

The second problem encountered is the lack of measured data supporting the "original noise level" or the "elevated peak levels" shown in Figure 1 of the NOI. As pointed out in the Naval Postgraduate School Report, the largest body of environmental noise measurements was developed by NTIA's ITS.[99] Although the ITS spectrum surveys provide an excellent database of noise at the time the measurements were performed, the measurements were conducted prior to the widespread deployment of many of the wireless radio services in operation today.[100] As the Naval Postgraduate School report points out, a similar set of measurements has not been performed by the ITS in a number of years, and it is believed that the existing data is only of limited historical interest.[101] The Commission's Interference Protection Working Group and

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97. Naval Postgraduate School Study at 380.

98. Federal Communications Commission, Technical Advisory Council, Fourth Meeting Report, at 23, Annex 4 (March 24, 2000).

99. National Telecommunications and Information Administration, Institute for Telecommunication Sciences, NTIA Report 97-334, *Broadband Spectrum Survey at San Diego, California* (December 1996); National Telecommunications and Information Administration, Institute for Telecommunication Sciences, NTIA Report 97-336, *Broadband Spectrum Survey at Los Angeles, California* (May 1997); National Telecommunications and Information Administration, Institute for Telecommunication Sciences, NTIA Report 99-367, *Broadband Spectrum Survey at San Francisco, California* May-June 1995 (July 1999); National Telecommunications and Information Administration, Institute for Telecommunication Sciences, NTIA Report 95-321, *Broadband Spectrum Survey at Denver, Colorado* (September 1995).

100. Naval Postgraduate School Report at 380.

101. *Id.*

TAC also indicated that a better understanding of the existing noise environment is necessary.[102]

Although based on a limited set of measured data, in one frequency band, the Naval Postgraduate School Report does raise the issue of spectrum saturation and the possible interference problems that could arise if the noise level is permitted to increase across a frequency band. NTIA believes that the lack of basic information of the existing noise environment greatly limits the ability of licensed and unlicensed system designers to conduct practical and useful system performance analysis. To begin addressing these problems, NTIA and the Commission should identify a list of candidate licensed and unlicensed frequency bands in which the emission or noise levels can be measured using standardized measurement systems. NTIA believes that these measurements can serve as a baseline for characterizing the existing emission environment in those bands, which can be used to determine whether the interference temperature model can be implemented in such a way as to achieve the Commission's longer term spectrum management objectives.

XXIII. CONCLUSION

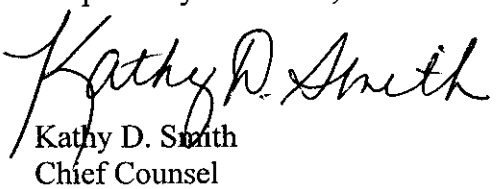
NTIA commends the Commission for initiating this proceeding to examine possibilities to expand the options for unlicensed device use while also providing certainty and predictability desired by licensed spectrum users. NTIA agrees with the Commission regarding the significant benefits that could be gained by increasing the spectrum access opportunities for unlicensed devices. The implementation of the interference temperature model and the use of interference mitigation techniques such as DFS and geo-location represent a shift in interference management from the transmitter to the receiver. The NOI identifies many technically challenging issues that

102. Federal Communications Commission, Spectrum Policy Task Force, Report of the Interference Temperature Working Group, at 28 (November 15, 2002); Federal Communications Commission, Technical Advisory Council, Sixth Meeting Report, at 9 (September 27, 2000).

must be addressed before the interference temperature model can be implemented in a frequency band. These technical issues include, but are not limited to, the development of radio service specific reference receiver parameters, the development of radio service specific maximum permissible interference limits and operational scenarios, and measurement of the existing RF signal environment in order to establish a proper baseline. Until these technical issues and the rights and responsibilities of licensed and unlicensed spectrum users have been resolved, wide spread implementation of the interference temperature model will not possible. Because of the sensitive nature of the operations in the restricted frequency bands, implementing the interference temperature model would be difficult if not impossible. However, if the initial implementation of the interference temperature model were limited to specific bands, for example, bands which have been transferred from the federal government, many of the technical issues listed above could be addressed and possibly resolved with minimal impact to incumbent commercial and federal government users. NTIA believes that active interference mitigation techniques such as DFS and geo-location hold great promise for facilitating sharing between licensed and unlicensed spectrum users. However, these techniques should not be employed until the supporting technical studies examining the specific characteristics of the licensed radio services and the unlicensed device applications have been completed.

For the foregoing reasons, NTIA submits these comments

Respectfully submitted,



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